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STRENGTH LOG OF AN OPEN BOREHOLE FROM INDEX TESTING OF CUTTINGS

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August 1985

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ENERGY RESEARCH PROGRAM
COAL RESEARCH LABORATORIES
DIVISION REPORT ERP/CRL 85-79(TR)

MICROMEDIA
JAN 21 1986

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by

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ABSTRACT

A method of determining the strength log of an open borehole from the index testing of cuttings is described with an example from the Sydney Coalfield, Nova Scotia. Work currently in progress to assess this method as an alternative to testing of cored borehole samples is described.

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DIAGRAMME DE RÉSISTANCE D'UN TROU DE SONDAGE OUVERT À PARTIR D'INDICES D'ANALYSES DE DÉBRIS DE FORAGE

par

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RÉSUMÉ

Une méthode visant à déterminer un diagramme de résistance d'un trou de sondage ouvert à partir d'indices d'analyses de débris de forage est décrite dans ce rapport à l'aide d'un exemple pris au champs houiller de Sydney en Nouvelle-Écosse. On présente de plus dans ce rapport, une description des travaux en cours dont le but est d'évaluer cette méthode comme solution de rechange pour analyser les échantillons de carottes de sondage.

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INTRODUCTION

A fundamental requirement in engineering design of underground openings is a knowledge of the properties of the strata around the opening. This is best accomplished by the drilling of cored boreholes and subsequent sample testing. Whilst this practise is common in many hard-rock mines and on civil engineering projects, underground coal mines have been slow to adopt it primarily on the basis of cost and inconvenience. It is therefore very difficult to obtain a reliable interpretaton of the lithological and physical properties of rocks around such excavations.

In many instances, large numbers of open holes are drilled in coal mines, for example for the purposes of gas drainage and bolt installation. An approach considered to determine the physical properties of the strata in such cases was the collection and subsequent index testing of borehole chippings. With a calibration factor determined experimentally this would allow the determination of the uniaxial compressive strength of the strata.

In order to test this possibility, chippings were collected from a methane drainage borehole drilled at Lingan mine in the 9E district tailgate The results of subsequent analysis are presented below.

TESTING PROGRAMME

SAMPLE COLLECTION

Chipping samples were collected from the mouth of the methane drainage hole over intervals of 0.75 m, corresponding to one drill rod length. They were bagged, labelled and returned to the laboratory where they were dried and examined, after which a lithological log of the borehole was drawn up. Index testing was then conducted on the chip fragments.

INDEX TESTING

The small size of the chippings dictated the use of the NCB Cone Indentor as the testing device (1). The test involves the determination of the hardness of the rock by its resistance to indentation by a standard conical tungsten carbide indentor. The force, P, required to cause a penetration, D, is determined from the collection of a calibrated spring.

Penetration is determined from successive readings of a micrometer and the indentor index, I_s, given by:

$$I_s = \frac{D}{P}$$

A maximum of 30 tests were conducted on each of the 22 samples collected, although in some cases the number of tests were less than this.

RESULTS

Table 1 shows a summary of the test results. No samples were collected from rods 1, 2 and 10. Figure 1 shows the lithological log of the borehole and a representation of the derived index and compressive strengths. The formula used to determine compressive strength, C, from the index data was:

$$C = I_s \times 24.8 \text{ MN/m}^2$$

This was derived by the NCB for coal measures rocks in the United Kingdom.

DISCUSSION

The changes in the index and strength logs in Figure 1 appear to conform broadly to the changes in lithology inferred from examination of the chippings. The derived compressive strengths reflect accurately the low strength of the mudstone member at 12.5 m above the seam compared to the other stronger sandstones, siltstones and limestones although no quantitative assessment of the accuracy of the derived results can be made. Uniaxial compressive strength data from other parts of the coalfield give strengths of approximately 61 MPa, 85 MPa and 30 MPa for siltstones, sandstones and mudstones respectively. The derived strength for the sandstone is markedly lower, but the siltstone and mudstone data compare well.

A contract entitled "Calibration of Cone Indentor Hardness Index with Traditional Uniaxial Compressive Strengths for Carboniferous Strata in the Sydney Coalfield" is currently being undertaken by the University College of Cape Breton in Sydney, N.S. The aim of the contract is to produce a calibration equation suitable for extensive use in the Sydney Coalfield, thus imparting increased accuracy to the method described above.

An extension of the work will see the determination of the triaxial properties of the chipping samples, from which a residual strength envelope can be obained. Since the peak and residual strength envelopes of samples tested triaxially and plotted as σ_1 vs σ_3 are sub-parallel and offset on the σ_1 axis by the uniaxial compressive strength, this phase if proven acceptable, will allow complete triaxial properties of the rock types to be determined.

CONCLUSIONS

In the absence of cored boreholes to provide samples for conventional physical properties testing, the collection of chippings from open boreholes allows the deviation of a strength log of the strata intersected by the borehole. The accuracy of the log will depend upon the efficiency of the sample collection method and the applicability of the formula used to derive the compressive strengths.

RECOMMENDATIONS

1. The method described above for the determination of borehole strength logs should be repeated, using a calibration equation derived for the Sydney Coalfield, to test its general applicability.
2. Residual triaxial properties of the chip samples should be determined and the peak envelopes inferred from them confirmed by direct testing.
3. If this method of determining strata properties is applicable, it should be implemented as part of the strata mechanics research programme.

ACKNOWLEDGEMENTS

The authors wish to acknowlege the assistance provided by personnel of the Cape Breton Development Corporation (CBDC) in the collection of samples for this testing programme.

REFERENCES

1. "NCB cone indentor"; MRDE Handbook; No. 5; National Coal Board, Mining Research and Development Establishment; April 1982.

Table 1 - Statistical results from methane drainage borehole Lingan Mine, New Waterford, N.S.

Sample Number	Mean I_s	UCS for mean (MN/m^2)	Median I_s	UCS for Median (MN/m^2)
3	2.58	63.98	2.62	64.98
4	2.47	61.26	2.44	60.51
5	2.73	67.70	2.84	70.43
6	2.93	72.66	2.98	73.90
7	2.85	70.68	2.79	69.19
8	2.73	67.70	2.67	66.22
9	2.66	65.97	2.49	61.75
11	2.67	66.22	2.82	69.94
12	2.84	70.43	2.70	66.96
13	2.78	68.94	2.79	69.19
14	2.44	60.51	2.44	60.51
15	2.45	60.76	2.49	61.75
16	2.40	59.52	2.42	60.02
17	2.48	61.50	2.42	60.02
18	2.36	58.53	2.31	57.29
19	1.73	42.90	1.61	39.93
20	1.79	44.39	1.67	41.42
21	1.89	46.87	1.81	44.89
22	2.19	54.31	2.29	56.79
23	2.93	72.66	3.02	74.90
24	2.50	62.00	2.49	61.75
25	2.56	63.49	2.62	64.98

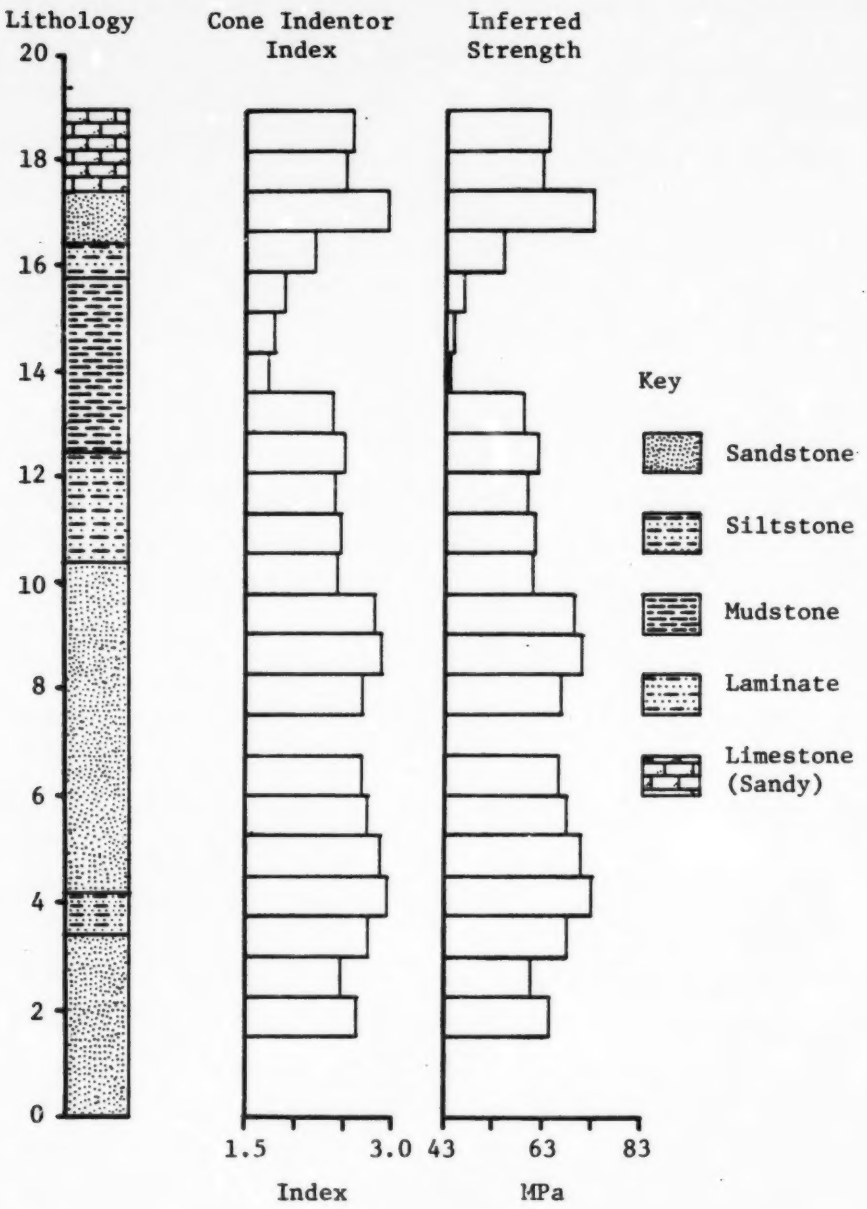

Figure 1 - Lithology, cone indentor index and inferred compressive strength log of methane drainage hole L9E1, 9E tailgate, Lingan Mine